LCA Case Studies

An Overall Assessment of Life Cycle Inventory Quality

Application to the Production of Polyethylene Bottles

Patrick Rousseaux[1], Eric Labouze[2], Young-Jin Suh[1], Isabelle Blanc[2], Valérie Gaveglia[3], Alain Navarro[4]

[1] Laboratoire d'Analyse Environnementale des Procédés et des Systèmes Industriels (LAEPSI), Institut National des Sciences Appliquées de Lyon, Villeurbanne, France
[2] BIO Intelligence Service S.A., Paris, France
[3] POLDEN, Insavalor S.A., Villeurbanne, France
[4] Association RECORD (Réseau Coopératif de Recherche sur les Déchets), Villeurbanne, France

Corresponding author: Patrick Rousseaux; e-mail: prous@insa.insa-lyon.fr

DOI: http://dx.doi.org/10.1065/lca2001.05.054

Abstract. A qualitative, quantitative, and overall quality assessment of life cycle inventory is suggested. The method is composed of five indicators which are set up at three levels of the inventory quality: flows, processes, and the system. The method allows one to assess the reliability of the method generating inventory data (justness of data, completeness of data, representativity of processes, repeatability of system definition) and at the same time to quantify the uncertainty of the resulting data made under the data generation method. LCA practitioners can finally decide the overall inventory quality through the information for the acceptability of the inventory result comparing the objective of quality and the cost necessary to improve the quality. The operation of the method was verified in the application to the production of polyethylene bottles. The proposed method was also found applicable for the validation of data in the ISO's LCA data documentation format.

Keywords: Case studies; data quality; life cycle inventory; polyethylene bottles; quality indicator; uncertainty

Introduction

For increasing credibility of the results of Life Cycle Assessment (LCA), one of the tasks left to LCA researchers is how to assess and manage the quality of the Life Cycle Inventory (LCI) (ISO 1997, ISO 1998). Attention has been paid to LCI quality assessment since the beginning of the LCA framework study and since different methods had been proposed (SETAC 1994). However, there is not yet a method commonly approved by LCA practitioners. It is why many LCA practitioners are exerting a great effort to develop assessment methods of LCI quality.

Here, we make a strict distinction of terminology between 'quality' and 'uncertainty' in order to make clear the principal concepts of this paper on the LCI quality assessment, even though the term of uncertainty is currently used instead of LCI quality (Huijregts 1998). According to their traditional meanings defined by international standards (ISO 1992, AFNOR 1994), the quality denotes the fitness for the objective of the data or product while the uncertainty of measurement indicates the estimation characterizing the extent to which the real value of the measurement exists. In this paper, we define 'LCI quality' as the summary statement representing the overall reliability of LCI result, 'quality indicator' as the set of indicators characterizing the LCI quality, and 'uncertainty' as one of the indicators, characterizing the variability of LCI data (Courtier 1994, Coulon et al. 1997). LCI data means raw data of elementary flows or their integrated data at the level of the product system (partial or complete life cycle).

The approaches for assessing the LCI quality proposed during the last few years can be classified in two main categories. The first one uses a data quality indicator such as geographic representation, age of data or the data acquisition method (Labouze et al. 1996, Weidema et al. 1996, Wrisberg et al. 1997). The second one represents the overall LCI quality in terms of uncertainty. The uncertainty of resulting inventory data of the system is obtained through the propagation analysis of uncertainties related to the raw data of each process (Chevalier et al. 1996, Heijungs 1996, Steen 1997).

Both of these approaches have critical drawbacks. The first method does not provide a condensed index for overall quality of the LCI, although data qualities of each unit process are presented by set of quality scores. The second is limited to only the uncertainty expressed by probability distribution or range of the resulting inventory data and it does not take into account the other aspects of LCI quality. However clear the uncertainty analysis is, the result may have low quality if the data used does not fit the objective of the study (Coulon et al. 1997). These facts lead some authors to explore the ways representing the LCI quality in terms of uncertainty starting from the data quality indicator approach. Some authors transformed the data quality scores into probability distributions of input data in order to simulate the uncertainty of the LCI result (Kennedy et al. 1997, Weidema et al. 1996). Other authors recommended the use of the data quality indicator approach just at the step of data collection and the determination of the probability distribution function or confidence interval of the selected data according to their data availability, independently as a subsequent step (Maurice et al. 2000).

In this paper, one data quality indicator approach is presented. It is based on the existing data quality approach but can be distinguished from others in the point that it is aimed at evaluating the overall quality in two aspects. At first, the result of quality scores attributed to three levels shows the causes, acceptability, and improvement ability of the uncertainty derived by the data generation method used. Secondly, uncertainty propagation analysis quantifies the variability of final inventory data derived by systematic errors of the data generation method and other random errors. To test its applicability, the proposed method was applied to the production of polyethylene bottles

The presented method was at first initiated by RE.CO.R.D (French research network on solid waste) and developed by BIO Intelligence Service and INSA de Lyon (LAEPSI/ POLDEN) for suggesting the practical guide of LCI quality assessment to the industry members of RE.CO.R.D (RECORD 1998).

1 Quality Assessment Method of Life Cycle Inventory Results

The procedure of LCI quality assessment is summarized in Figure 1 with parameters to be determined at each step.

1.1 Qualification of inventory data

LCI quality is analyzed at the same time in the two following aspects, the reliability of data generation method and the variability of the resulting data (uncertainty) obtained under the given method.

1) **Reliability of the method of data generation.** The data generation method performed is analyzed concerning the degree to which it has an aptitude to provide accurate data (justness), to include all the potential population in existence (completeness), to reflect the true population of interest (representativity) and to repeat the same result under a given method (repeatability). These indicators were set up at 3 levels, i.e. flow, process, and system, deciding which level is related to the quality to be assessed by the indicator (Table 1). For instance, the justness of LCI should be evaluated at each elementary data, or at the flow level while the assessment of geographical representativity is sufficient at the process level due to the uniformity of geographical conditions of the overall data set describing each process. For the quantitative assessment, the quality scores from 1 to 5, 1 being the best, are attributed in the detailed components of the 4 indicators above (Table 2). This proposed method was developed based on the works of Weidema et al. (1994) and Wrisberg et al. (1997). The innovative change from prior works consists of the introduction of 'repeatability', which indicates the aptitude to generate the same LCI result under the same rules for inclusion/exclusion of flow and process, definition of functional unit, and allocation. That is, it concerns how transparent, how justified, and how consistently applied the rules of choice are. Some specific criteria of the score were modified as well. For instance, we put the criteria, 2, 5, 10, and 15 years for time-related representativity as opposed to the 3, 6, 10, and 15 years in Weidema's proposition.

2) **Variability of the resulting data (uncertainty).** In general, plural values exist which show a probability distribution or distribution interval when one repeats the data generation on the same object. The distribution is mainly caused by the inadequate or imprecise data generation methods which are analyzed in the preceding step (1) and as well due to random uncertainty which is inherent in the natural phenomena. We call this variability of data **uncertainty.** The variations of raw data of flows are determined at the moment of data generation through sample survey, reference data, calculation, or even assumption. These variations are propagated when one integrates the data which have the same identity (e.g. CO_2 emissions) from each process to total system. The final variation of the integrated data, here called uncertainty, was calculated through Monte Carlo simulation in this paper. This technique allows one to simulate the probability distribution of the integrated data (output variable) by randomly sampling the raw data (input variable) based on their statistical distributions. In general, the proce-

Table 1: Indicators of LCI data quality

Level	Quality Indicator	Quality Component
Flow	Justness	1. Statistical representativity of data 2. Age of data 3. Method of data acquisition
Process	Completeness	4. Exhaustiveness of identified flow 5. Aggregation of flows 6. Mass balance equilibrium
Process	Representativity	7. Geographical 8. Time-related 9. Technology
System	Repeatability	10. Rule of process inclusion/exclusion 11. Rule of flow inclusion/exclusion 12. Rule of functional unit definition 13. Rule of allocation
Flow / System	Uncertainty	14. Data variability (propagation on the system)

Table 2: LCI data quality assessment matrix

Component \ Score	1	2	3	4	5
		Indicator 1 : Justness of data			
1. Statistical representativity of data	Representative data from a sufficient sample of sites (>30) over an adequate period	Representative data from a smaller number of sites (<30) but for an adequate period	Representative data from a smaller number of sites (<30)	Data from one site	Representativeness unknown
2. Age of data	Less than 2 years	2 – 5 years	5 – 10 years	10 – 15 years	Age unknown
3. Method of data acquisition	Calculated or measured data verified by external examiner	Calculated or measured data verified	Calculated or measured data not verified	Data estimated by expert	Origin unknown
		Indicator 2 : Completeness of data			
4. Exhaustiveness of identified flow	By comparison with references (others LCI), no significant difference in the nature of identified flows	By comparison with references, some flows are missed but their qualitative importance is minor considering the objective of study	By comparison with references, some flows are missed. Their percentage is inferior to x% of total flows of the process	By comparison with references, some flows are missed. Their percentage is superior to x% of total flows of the process	No bibliography study, type and number of missing flow unknown
5. Aggregation of flows	Any flow is not aggregated	Quantitatively non important flows are aggregated	Quantitatively important flows having similar environmental properties are aggregated	Quantitatively important flows having different environmental properties are aggregated	Type of aggregation of different flows is not known
6. Mass balance equilibrium		Quantitative parameter directly calculated		Mass balance not calculated	
		Indicator 3 : Representativity of process			
7. Geographical representativity	Data in direct relation with the area of study	Average data from larger area in which the area under study is included	Data from different area with similar production conditions	Data from area slightly similar production conditions	Data from unknown area or area with very different production conditions
8. Time-related representativity	Less than 2 years of difference to year of study	Less than 5 years of difference	Less than 10 years of difference	Less than 15 years of difference	More than 15 years of difference or age of data unknown
9. Technology representativity	Data from enterprises, processes, and materials under study	Data from processes and materials under study but from different enterprises	Data from processes and materials under study but from different technology	Data on related processes or materials but same technology	Data on related processes or materials but different technology
		Indicator 4 : Repeatability of system (Rule of choice)			
10. Rule of process inclusion/exclusion	Transparent, justified; homogeneous application	Transparent, justified; non-homogeneous application	Transparent, not justified; non-homogeneous application	Not transparent on rule of exclusion but specification of inclusion	Criteria unknown
11. Rule of flow inclusion/ exclusion	3 accumulated criteria on system: mass, energy, and emissions	1 accumulated criteria on system: mass, energy, or emissions	2 non accumulated criteria on system: mass/process and energy/and process	1 non accumulated criteria on system: mass/process or energy/and process	Criteria unknown
12. Rule of Functional Unit (FU)	FU includes explicitly at least 3 following units: function, product, time	FU includes implicitly at least 3 following units: function, product, time	FU includes explicitly at least 2 of 3 units preceding	FU includes explicitly at least 1 of 3 units preceding	FU is not defined
13. Rule of allocation	Transparent, justified and relevant; homogeneous application	Transparent, justified and relevant; non-homogeneous application	Transparent, justified but not relevant	Transparent, not justified; non-homogeneous application	Not transparent
		Indicator 5 : uncertainty of resulting data			
14. Data variability			Variability of integrated data at the system level		

dure of Monte Carlo simulation consists of seven steps as follows (Blanc et al. 1999):

(1) Explicit formulation of the relation equation jointing the target output variable to input variable
(2) Determination of the uncertainties or the statistical functions of input variables
(3) Random sampling of input variables in the range of their variations
(4) Calculation of output variable
(5) Stock of the result and iteration of steps (3) and (4) several thousand times
(6) Figuration of the probability curve of output variable
(7) Interpretation of the curve and calculation of the uncertainty (e.g. coefficient of variance)

1.2 Representation of the overall quality of LCI

The quality is appreciated depending on how well to respond to the predefined objective according to its definition. In the LCA, too, one should decide the objective of LCI quality together with the objective of the LCA in the first phase of LCA in order to assess the quality. The objective is represented by the acceptable criteria of the quality score for each component of quality indicators. For instance, if the objective of quality is 3, the scores 1, 2, and 3 are said to be 'acceptable' when 4 and 5 are said to be 'not acceptable'. The **coefficient of acceptability** is calculated here as the percentage of the acceptable result in the total LCI results at each indicator component (e.g. when the objective is 2 and the number of acceptable flows is 13 in 24 flows, or coefficient of acceptability: 13/24 * 100 = 54% for flows of full system in component 3, Table 5). This coefficient is used to respond to the question: Is the LCI quality acceptable with respect to the fixed objective?

Besides, the **coefficient of variability** is obtained from the variance of quality score divided by the average of the scores attributed in the same component of indicators or in the same indicator (e.g. 0.326/1.47 * 100 = 22.2% for flows of full system in indicator 1, with the variance of scores being 0.326 and the average being 1.47, Table 5). This coefficient allows one to analyze the coherence and to evaluate the improvement potential of the quality. It is used to answer the question: Can the LCI be improved with the acceptable ratio of cost/efficiency?

The result of the assessment is summarized in Table 5 with the coefficient of acceptability, coefficient of variability, and uncertainty, like the result of the case study. Simply looking over the coefficient of acceptability enables one to identify and compare the qualities of the LCI results with predefined quality objectives. In the event that the assessment result does not correspond to the predefined objectives, the resulting data is rejected and one returns to the data generation step. Or it is also expected to reconsider the objectives of quality and even to modify the objective of the LCA (**Fig. 1**). The coefficient of variability enables one to determine the effort necessary to improve the LCI quality. Finally, the uncertainty has the role of a condensed indicator representing the result of the LCI quality quantitatively, but without the statement for the uncertainty causes. Therefore, the coefficient of acceptability, coefficient of variability, and uncertainty are complementary to one another for representing and interpreting the overall LCI quality.

2 Application to the Production of Plastic Bottles

The objective of this LCA is to assess the potential environmental impact of polyethylene (PE) bottles (RECORD 1998). The real study system (life cycle of the bottle) is so immense and encompasses PE manufacturing, bottle manufacturing, bottle refilling, bottle use, elimination of used bottle, production of required energy, and transport. For a simple illustration of the proposed method, we considered three main processes (**Fig. 2**):

- Process 1: production of energy necessary to the production of PE via fuel thermal system
- Process 2: production of PE
- Process 3: elimination of used bottles through incineration

The functional unit was chosen as the production of 1 kg of PE to be utilized for the production of bottles. A simple inven-

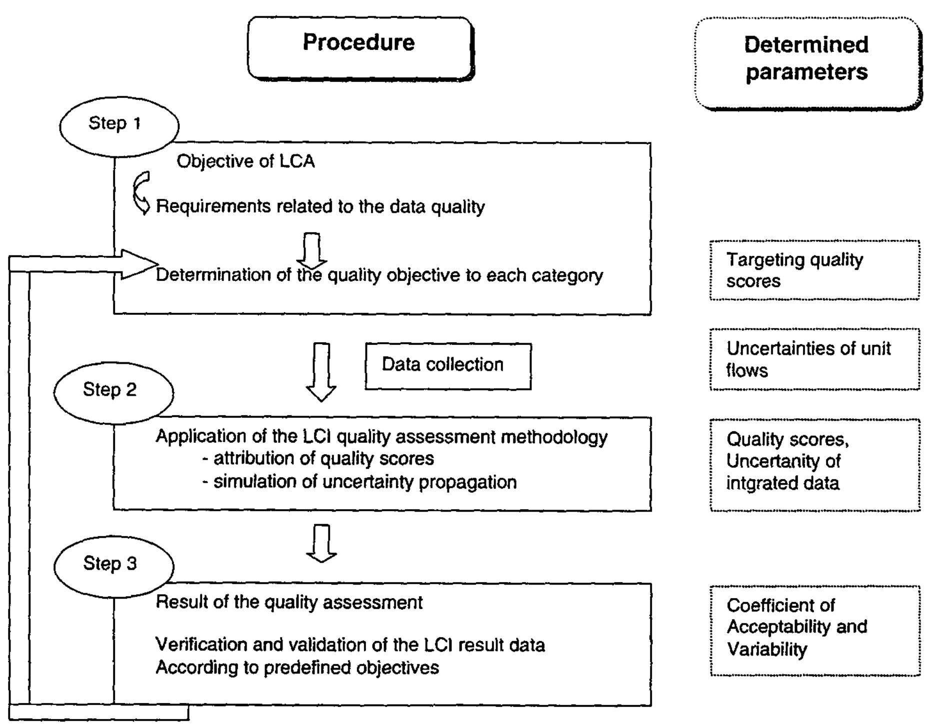

Fig. 1: Procedure of LCI quality assessment

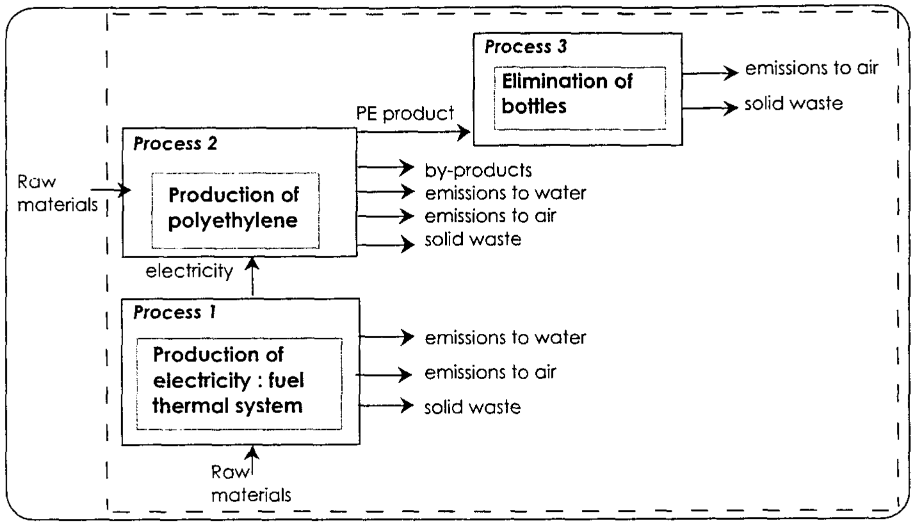

Fig. 2: Partial life cycle of PE bottles (study system)

tory was set up for each process considering raw material inputs, auxiliary material inputs, and environmental burdens (**Table 3**) (Habersatter 1990, Boustead 1993, Rousseaux 1993).

According to the qualification matrix proposed in the preceding part, scores are at first attributed to flows of each process for justness of data (**Table 4**), to processes for completeness of data and representativity of process, and finally to a system for repeatability of data. The quality objective was arbitrary determined as 2 for all indicator components. For justness of data, the scores attributed to flows of each process are further converted, in proportion to the mass contribution, into scores of the flows integrated to the system according to the same environmental intervention. For instance, when the justness score of CO_2 emission is '1' for process 1, '2' for process 2, and '1' for process 3, and since the weight ratio of CO_2 emission of process 1 to total emission is '0.06', '0.19' for process 2, and '0.75' for process 3 (Table 3), the justness score of CO_2 emission of the system is calculated as the sum of the justness scores for each process weighted by the mass contribution, e.g. justness of the data for CO_2 emission on the system: $1*0.06 + 2*0.19 + 1*0.75 = 1.19$ (Table 5, Appendix).

Monte Carlo simulation was used for the calculation of uncertainties of each environmental intervention integrated on the system. For illustration, the simulation result with arbitrary input variation of 30% is presented for two important variables of CO_2 and SO_2 emissions (Table 5, Appendix).

Table 3: Inventory analysis for production and treatment of 1 kg of PE

		Total	Process 1		Process 2		Process 3	
		(g)	(g)	%	(g)	%	(g)	%
Inputs								
	petrol	50552	552	1	50000	99	0	0
	additives	10	0	0	10	100	0	0
	water	1000	0	0	1000	100	0	0
	treated PE	1000	0	0	0	0	1000	100
	oxygen	7050	196	3	0	0	6854	97
	nitrogen	22613	0	0	0	0	22613	100
Outputs								
Waterborne emissions	Inorganic salts	25	0	0	25	100	0	0
	TSS	$1.74\ 10^{-3}$	$1.74\ 10^{-3}$	100	0	0	0	0
	phenol	4	$1.74\ 10^{-5}$	0	4	100	0	0
	non polycyclic HC	$1.74\ 10^{-4}$	$1.74\ 10^{-4}$	100	0	0	0	0
Atmospheric emissions	dust	0.11496	0.06496	56.5	0	0	0.05	43.5
	CO	2.09	0.12	5.6	0.67	32.1	1.3	62.3
	NO_x	7.27	0.98	13.5	1.09	15.0	5.2	71.5
	SO_2	3.01	1.62	53.9	0.99	32.8	0.4	13.3
	CH_4	$8.12\ 10^{-3}$	$8.12\ 10^{-3}$	100	0	0	0	0
	HC	11.37	0.07	0.6	11.3	99.4	0	0
	CO_2	4208.38	267.38	**6.4**	800	**19.0**	3141	**74.6**
Solid wastes	ashes	3.944	3.944	100	0	0	0	0
	by-products	46929.34	469.34	1	46460	99	0	0
	others	4	0	0	4	100	0	0

Table 4: Assessment result of justness in flows of process 1

Process 1		Total flow (g)	Flows of process 1 (g)	Mass contribution	Justness J1*	J2	J3
Inputs							
	petrol	50552	552	0.01	2	2	1
	oxygen	7050	196	0.03	1	2	1
Outputs							
Waterborne emissions	TSS	$1.74\ 10^{-3}$	$1.74\ 10^{-3}$	1.0	1	2	1
	phenol	4	$1.74\ 10^{-5}$	0.0	1	2	1
	non polycyclic HC	$1.74\ 10^{-4}$	$1.74\ 10^{-4}$	1.0	1	2	1
Atmospheric emissions	dust	0.11496	0.06496	0.57	1	2	1
	CO	2.09	0.12	0.06	1	2	1
	NO_x	7.27	0.98	0.14	1	2	1
	SO_2	3.01	1.62	0.54	1	2	1
	CH_4	$8.12\ 10^{-3}$	$8.12\ 10^{-3}$	1.0	1	2	1
	HC	11.37	0.07	0.0	1	2	1
	CO_2	4208.38	267.38	0.06	1	2	1
Solid wastes	ashes	3.944	3.944	1.0	2	2	1
	by-products	46929.34	469.34	0.01	2	2	1

*) J1: statistical representativity of data; J2: age of data; J3: method of data acquisition

Example : Simulation of uncertainty of SO_2 and CO_2 emissions from the system

- Step (1) Formalization of the relation equation

  $SO_{2,\,system} = SO_{2,\,process1} + SO_{2,\,process2} + var1 \cdot Q_{PE}$

  $CO_{2,\,system} = CO_{2,\,process1} + CO_{2,\,process2} + (var1 \cdot Q_{PE} - var2 \cdot Q_{CO})$

  With $SO_{2,\,system}$: quantity of SO_2 emissions from the system

  $SO_{2,\,process\,i}$: quantity of SO_2 emissions from process i

  var1, var2: process parameters of process 3

  Q_{PE}: quantity of PE production, Q_{CO}: CO output of process 3
- Step (2) Variations of input data were arbitrarily determined as 30%.
- Step (3) to (6) presented in the preceding part are automatically carried out by the software.
- Step (7) The resulting uncertainty of the integrated data of the system for SO_2 and CO_2 emissions are 18.34% and 19.23%, respectively when their raw data of each process demonstrate a variation of 30%.

The following conclusion was obtained from the application of the LCI quality assessment method in the case study:

- The justness of data and the representativity of processes are satisfactory while the completeness of data and repeatability of the system are unsatisfactory.
- For improving completeness of data, a greater effort is necessary for avoiding the aggregation of flows than for retaining the exhaustiveness of flows.
- The uncertainty of SO_2 and CO_2 emissions are obtained in 18.34% and 19.23%, respectively, thus relatively lower than the input variation of 30%.

3 Conclusion and Outlook

3.1 Features of the proposed LCI quality assessment method

The proposed method can be distinguished from the existing methods using data quality indicators in the following points:

- Inventory quality indicators were proposed to assess the reliability of the method by which the inventory data were generated (justness of data, completeness of data, representativity of process, repeatability of system definition) and also the uncertainty of the resulting inventory made by the given method. The five indicators are further detailed in 14 components to which quality scores are actually attributed.
- The indicators are established on the three levels of data quality assessment (flows, processes, and system) according to their relevance to the LCI quality. An indicator at the system level, repeatability of system definition, was added for the first time while other methods ended at the steps just to assess the justness of flows and the representativity of the processes.
- The evaluation of overall LCI quality is carried out with coefficient of acceptability which indicates the percentage of acceptable data compared with the objective of quality, coefficient of variability which helps to appreciate the degree of homogeneity of quality scores, and uncertainty which shows the statistical distribution of resulting inventory data.

For each indicator, the scoring matrix was proposed with the exhaustive criteria of the evaluation. These criteria are expressed in general terms to be applied to any circumstance of the study and it makes the matrix very general. The characteristic of matrix, being general, gives the strict reference of the assessment. On the other hand, the method introducing the objective of quality gives a great flexibility in the evaluation of inventory result and enables the assessment module fitting the specific demand for LCI quality.

In conclusion, the proposed method helps LCA practitioners in decision-making by giving information for the ac-

ceptability of the inventory result comparing the objective of quality and for the cost necessary to improve the quality. The users can also quantify the uncertainty of their inventory data and specify the causes of the uncertainty through this method completed by qualitative and quantitative quality indicators. The applicability of the method was verified through the case study on the production of PE bottles.

3.2 Further considerations

Although the method of this paper covers the qualitative and quantitative aspects of the LCI quality assessment, it is true that the focus is put on the former. Mentioning the factors to be considered further for efficiently generating the credible inventory in practice, one of them is the uncertainty simulation method. Although the Monte Carlo method is now well known for the technique of uncertainty analysis, it needs to explore other methods such as interval analysis, fuzzy arithmetic, and probability-bound analysis considering the calculation speed and the type of available data. The other factors are data-importance analysis and sensitivity analysis. Since it is actually difficult to quantify all the uncertainties of enormous raw data, it is necessary to select the significant data through the importance analysis and to check their influence to the inventory result through sensitivity analysis.

The method presented can be used not only to evaluate LCI result at the phase of interpretation, but also to obtain a high quality of inventory data at the early phase of inventory building by following the quality criteria of the method. For the last purpose, LCI data format to fit the quality criteria is naturally required. In the LCA societies as well, a standard LCA data documentation format has been required for long in order to facilitate the data exchange and to confirm their quality. The result has come out as ISO/CD 14048 and it is now being revised to be a standard. According to the document (ISO/CD 14048), LCI data quality is globally stated at first by data generator and more detail validation is made by the third validator in the part of **modeling and validation** of the document. However, the document does not describe any specific procedure for validation, but a minimum structure such as method, procedure, result, and validator. The LCI quality criteria specified on the proposed method was found to cover almost parameters of the data categories and modeling choices presented on the ISO's document. Thus, the assessment method of this paper would be one of the LCA data quality methods for the LCA data documentation format of ISO.

References

AFNOR (1994): Vocabulaire international des termes fondamentaux et généraux de métrologie. NF X 07-001. Association Française de Normalisation

Blanc I, Labouze E (1999): Analyse du cycle de vie-Evaluation de la qualité des données. Techniques de l'ingénieur, Vol G1 (G5750), 9 pp

Boustead I (1993): Eco-profiles of the European plastics industry, Report 3: Polyethylene and Polypropylene. Brussels (Belgium), European Center for Plastics in the Environment (PWMI), 20 pp

Chevalier J-L, Le Téno J-F (1996): Life cycle analysis with ill-defined data and its application to building products. Int J LCA 1 (2) 90-96

Coulon R, Camobreco V, Teulon H, Besnainou J (1997): Data quality and uncertainty in LCI. Int J LCA 2 (3) 178-182

Courtier J-C (1994): Vocabulaire de la mesure. Techniques de l'ingénieur, Vol R11 (R113), 14 pp

Habersatter K (1990): Cahier de l'environnement n°132: Bilan écologique des matériaux d'emballage, état en 1990. Bern (Swiss), BUWAL, 262 pp

Heijungs R (1996): Identification of key issues for further investigation in improving the reliability of life-cycle assessments. J Cleaner Prod 4 (3-4) 159-166

Huijbregts MAJ (1998): Application of uncertainty and variability in LCA, Part I – A general framework for the analysis of uncertainty and variability in life cycle assessment. Int J LCA 3 (5) 273-280

ISO (1992): Principes généraux concernant les grandeurs, les unités et les symboles. ISO 31/O. International Standard Organization

ISO (1997): Environmental Management – Life Cycle Assessment – General Principles and Framework. ISO 14040. International Standard Organization

ISO (1998): Environmental Management – Life Cycle Assessment – Goal and Scope Definition – Inventory Analysis. ISO 14041. International Standard Organization

ISO (2000): Environmental Management – Life Cycle Assessment – LCA data documentation format. ISO/CD 14048. International Standard Organization

Kennedy DJ, Montgomery DC, Rollier DA, Keats JB (1997): Assessing input data uncertainty in life cycle inventory models. Int J LCA 2 (4) 229-239

Labouze E, Roederer O (1996): A suggested rating system to assess the data quality in your LCA study. 6th annual meeting of SETAC-Europe, Giardini Naxos Taormina, Italy

Maurice B, Frischknecht R, Coelho-Schwirtz V, Hungerbühler K (2000): Uncertainty analysis in life cycle inventory – Application to the production of electricity with French coal power plants. J Cleaner Prod 8, 95-108

RECORD (1998): Evaluation de la qualité des données d'inventaires des ACV. Lyon(Fr), 2 Vols, 45 pp and 76 pp. Report for Association RE.CO.R.D n° 96-1002/1A, -1003/1A

Rousseaux P (1993): Evaluation comparative de l'impact environnemental global (ECIEG) du cycle des produits. Thesis, Gestion et traitement du déchet : INSA de Lyon, 1993, 276 pp

SETAC (1994): Life-cycle assessment data quality – A conceptual framework. Florida (USA). Society of Environmental Toxicology and Chemistry, 157 pp

Steen B (1997): On uncertainty and sensitivity of LCA-based priority setting. J Cleaner Prod 5 (4) 255-262

Weidema BP, Wesnaes MS (1996): Data quality management for life cycle inventories – An example of using data quality indicators. J Cleaner Prod 4 (3-4) 167-174

Wrisberg N, Lindeijer E, Mulders P, RAM A, Van der Ven B, Van der Wel H (1997): A semi-quantitative approach for assessing data quality in LCA. 7th annual meeting of SETAC-Europe, Amsterdam, the Netherlands

Received: June 16th, 2000
Accepted: April 3rd, 2001
OnlineFirst: May 4th, 2001

Appendix: Table 5: Summary table of quality score result

		Justness			Completeness			Representativity			Repeatability				Uncertainty
		Indicator 1			Indicator 2			Indicator 3			Indicator 4				Indicator 5
Component		1	2	3	4	5	6	7	8	9	10	11	12	13	14
FLOWS (per process)															
PROCESS 1															
FLOW OBJECTIVE		2	2	2											
variability(%)* RESULT			9.7												
acceptability(%) RESULT		100	100	100											
PROCESS 2															
FLOW OBJECTIVE		2	2	2											
variability(%)* RESULT			9.0												
acceptability(%) RESULT		100	100	100											
PROCESS 3															
FLOW OBJECTIVE		2	2	2											
variability(%)* RESULT			34.8												
acceptability(%) RESULT		100	100	100											
PROCESSES															
PROCESSES OBJECTIVE					2	2	95%	2	2	2					
PROCESS 1 RESULT					5	4	99%	2	2	2					
PROCESS 2 RESULT					5	4	94%	1	1	3					
PROCESS 3 RESULT					1	2	100%	1	1	2					
variability(%)* RESULT	(exhaustitivity)				51.4										
variability(%)* RESULT	(aggregation)					28.3									
acceptability(%) RESULT					33	33		100	100	100					
SYSTEM															
OBJECTIVE											2	2	2	2	
SYSTEM RESULT											2	3	3	3	
acceptability(%) RESULT											100	0	0	0	
FLOWS (in full system)															
FLOW OBJECTIVE		2	2	2											
(i) petrol RESULT		1.01	1.01	2.98											
(i) additives RESULT		1.00	1.00	3.00											
(i) water RESULT		1.00	1.00	3.00											
(p) PE bottle RESULT		1.00	1.00	1.00											
(i) oxygen RESULT		1.00	1.03	1.00											
(i) nitrogen RESULT		1.00	1.00	1.00											
(i) PE products RESULT		1.00	1.00	3.00											
(p) by-products RESULT		1.01	1.01	2.98											
(w) inorganic salts RESULT		1.00	1.00	3.00											
(w) TSS RESULT		1.00	1.00	1.00											
(w) phenol RESULT		1.00	2.00	1.00											
(w) non polycy. HC RESULT		1.00	1.00	3.00											
(a) H_2O RESULT		1.00	2.00	1.00											
(a) O_2 RESULT		1.00	1.00	1.00											
(a) N_2 RESULT		1.00	1.00	1.00											
(a) dust RESULT		1.43	1.57	1.87											
(a) CO RESULT		1.94	1.06	2.89											
(a) HC (unspec.) RESULT		2.00	1.00	3.00											
(a) NOx RESULT		1.87	1.13	2.73											
(a) SO_2 RESULT		1.46	1.54	1.92											**18.34% (**)**
(a) CH_4 RESULT		1.00	2.00	1.00											
(a) CO_2 RESULT		**1.19**	1.06	1.38											**19.23% (**)**
solid waste RESULT		1.00	1.00	3.00											
ashes RESULT		2.00	2.00	1.00											
variability(%)* RESULT			**22.2**												
acceptability(%) RESULT		100	100	**54**											

(*) for three components of either justness or completness, expressed by % of the average value
(**) corresponding to the case of all input uncertainties being 30%
(i): input; (p): product; (w): waterborne emissions; (a): atmospheric emissions